Carbon Sequestration: Super Critical CO_2's effect on subsurface brines in the Illinois Basin

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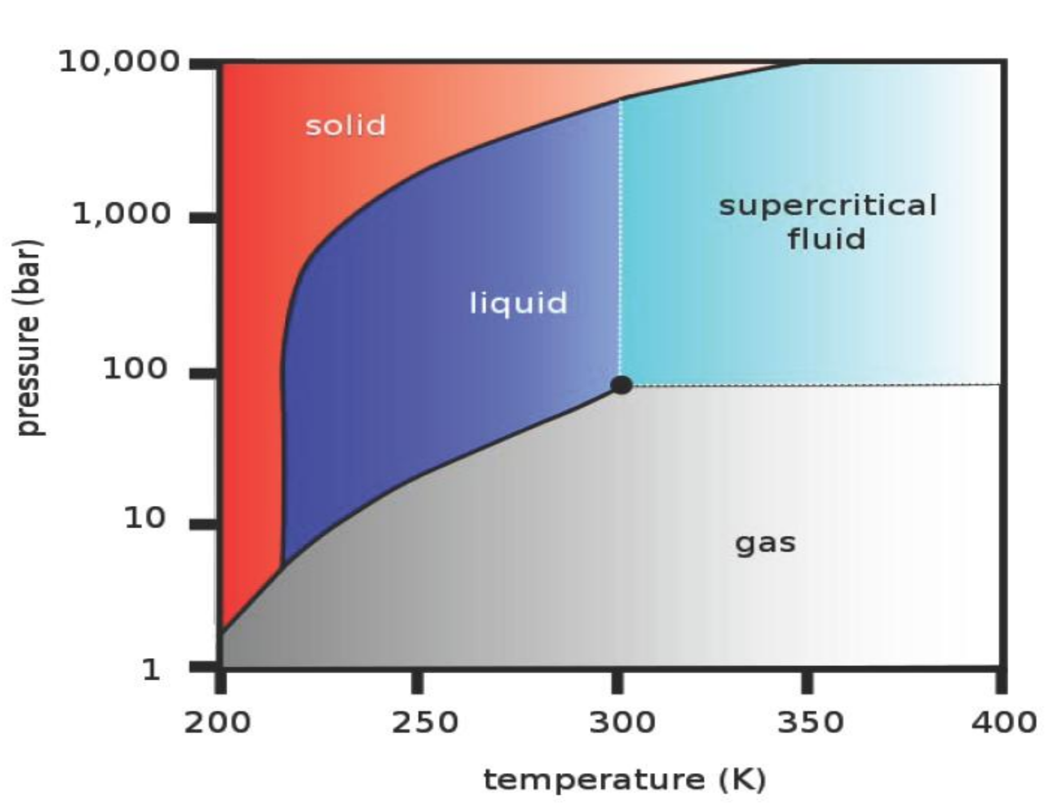
Abstract

The impact of CO_2 on global warming has become a reality and major CO_2 producers must take steps to address a 40% increase in concentration that has occurred globally since the early 1800's. This study looked at the relationship between supercritical CO_2 and sandstone reservoirs in the Illinois Basin. Specifically the Mt. Simon and St. Peter sandstone were studied and their characteristics were compared to data collected in the Tough-React model (Xu) response for a normalized sandstone. The data compared showed that with an increase in depth, the ion concentration increases allowing for more secondary mineralization to occur along with the formation of clays. Major minerals are present in both the Mt. Simon and St. Peter that raise concerns for sequestering CO_2.

What is Super Critical CO_2?



Physiochemical properties:
- High density
- Solubility's approaching the liquid phase
- Diffusivity approaching the gas phase

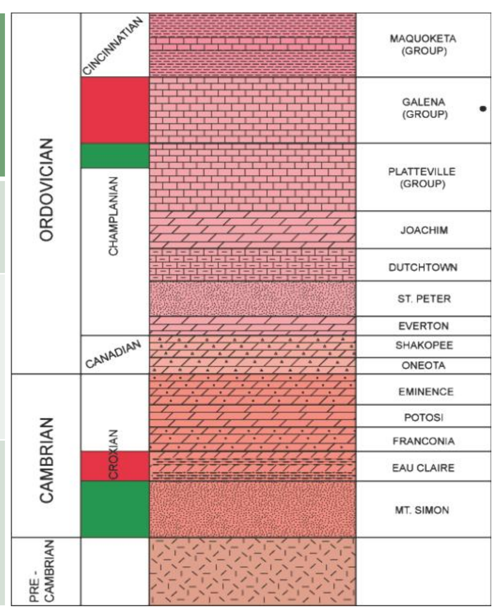
Minimum constraints:
- 74 bars
- 303 K
- 2,500ft

Geothermal Data:
- 303 K/km
- 105 bar/km

Mt.Simon and St. Peter Sandstone

	Mt. Simon Sandstone	St. Peter Sandstone	Tough React (Xu)
Porosity	8%-18%	10%-40%	10%-30%
Type	Feldspathic Qtz Sand	Qtz Arenite	Normalized Qtz Lithic Arkose
Thickness	50ft. – 2000* ft.	0 ft.-100 ft.	10m*

Porosity and Thickness estimates based on well data from the Illinois Basin



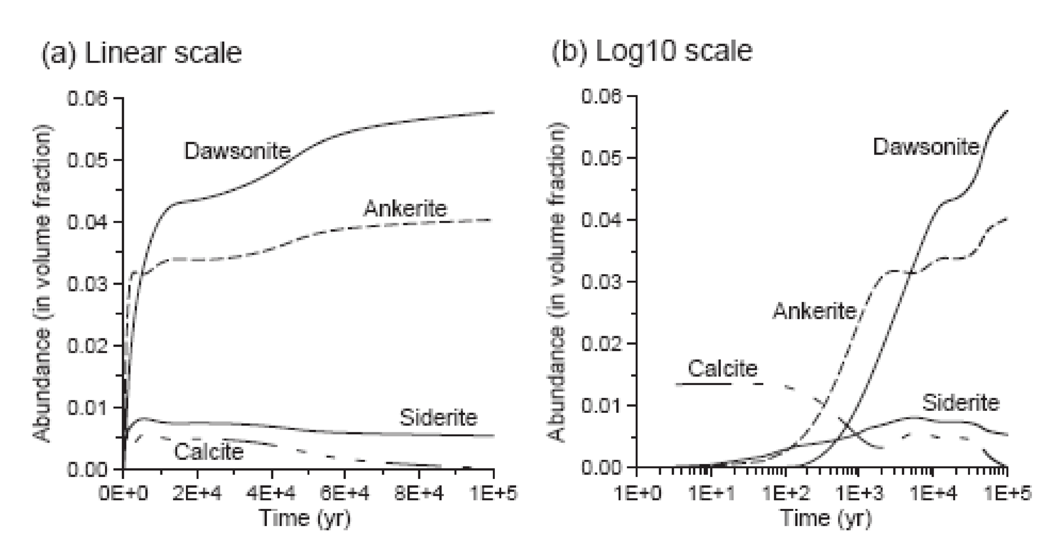
Red: Suggested Cap Rock
Green: CO_2 Reservoirs

Xu Et Al Normalized Sandstone

Major Constituents:
Quartz, Kaolinite, Calcite, Illite, Oligioclase, K-Feldspar, Hematite, Chlorite, Na-Smectite

General Data:
- Normalized Sandstone contains 56% Quartz, 28% Feldspar and 16% Lithic fragments
- Testing revealed up to 30% of the medium formed secondary minerals
- Porosity lowering carbonates
- Permeability lowering clay minerals

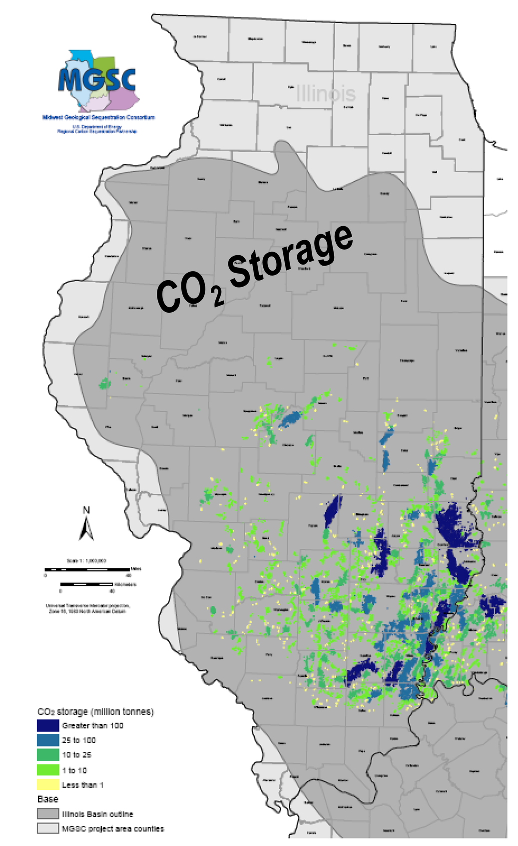
Xu Et Al Normalized Sandstone Results



Results:
- pH changes from a rapid increase in total carbonate content
- pH decrease from increased acidity and corrosiveness
- CO_2 trapping minerals Dawsonite and Siderite form
- 30% of original rock body went to secondary mineral formation after injection
- Lower porosity from CO_2 mineral trapping.
- Feldspar dissolution to form clays

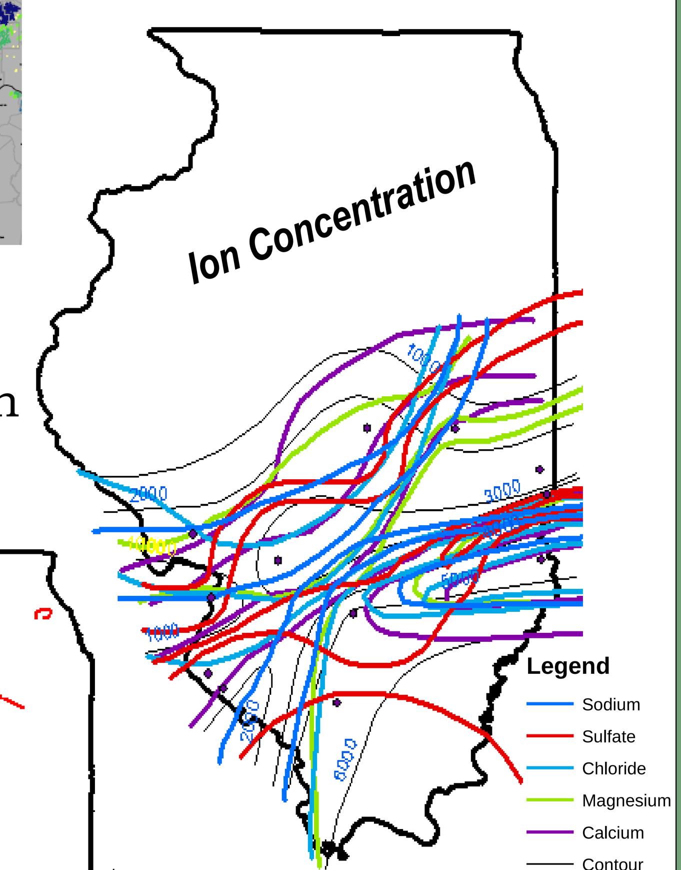
Secondary Constituents:
Anhydrite, Low Albite, Dawsonite, Alunite, Siderite, Magnesite, Ankerite

ArcGIS Data

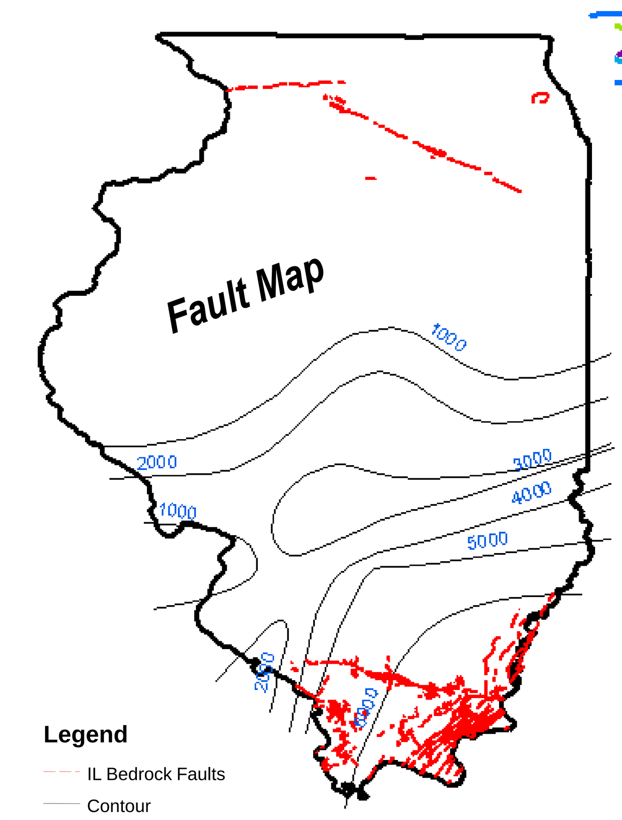


Storage Capacity:
- 30 billion tons(low)
- 130 billion tons (high)

Worldwide Capacity:
- 3,300 gigatonnes
- 13,000 gigatonnes

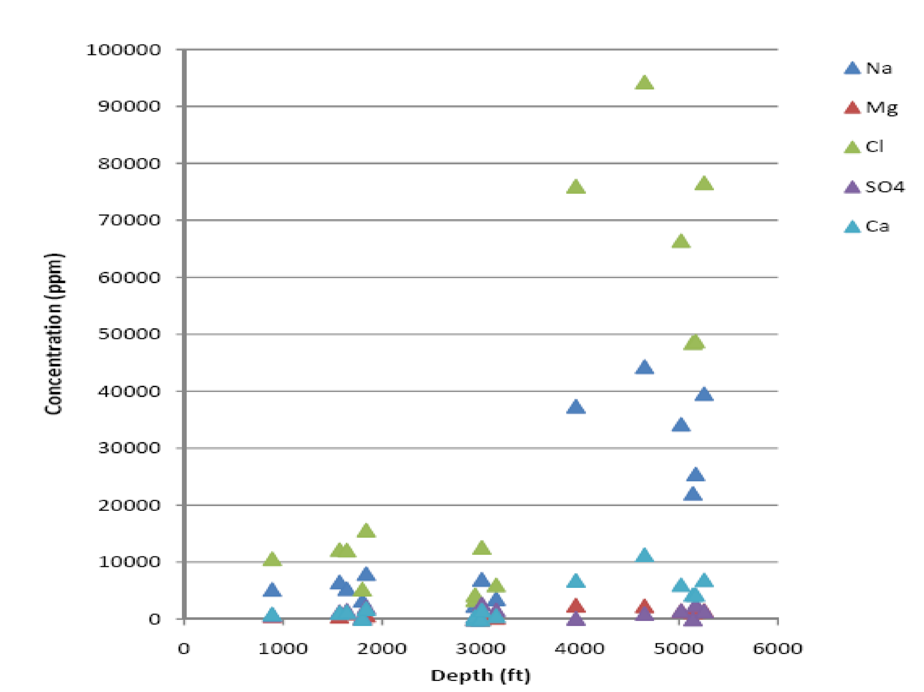


Trend:
- Increased ionization with depth



Illinois Basin:
- Highly Un-fractured
- Varying Thickness
- Limited Faulting

Water Chemistry of St. Peter Sandstone



Concentration vs. Depth Relationship:
- Even distribution of SO_4 and Mg
- Increasing concentration of Na, Cl, and Ca
- Brines explained by high concentration of Na and Cl

Conclusions

Super critical CO_2 occurs at a low temperature and pressure attained at a depth of approximately 2500'. With an increase in depth there is a direct correlation between higher anion and cation concentration. This increase allows for more secondary mineralization to occur at known activation energies. When super critical CO_2 is injected into the saturated brine the reservoir becomes acidic and corrosive. The reactions will precipitate minerals and dissolve rocks causing both a decreases in porosity and permeability over the time of a project. Most mineralization and change occurs within the first 10,000 years which could impact the overall effectiveness. Our ability to inject CO_2 into the subsurface will lower yearly emissions and further our knowledge concerning sequestered CO_2.

Acknowledgments

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Methods

Analysis of :
- TGS Water Chemistry Data Set.
- Tough React Data Set (Xu).
- AEP Carbon Sequestration Data Set.
- Scientific Papers from GSW.
- SES/SEI Carbon Sequestration Workshop

References

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Future Work

Chemical weathering in saturated CO_2/Brine reservoirs and its formation of clays.